Situation Analysis Report: Raichur Transformation Lab

Sustainable Transition Explorations in Water and Agriculture for Resilient Dryland Systems (STEWARDS)

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Executive Summary

Despite government efforts to expand irrigation infrastructure, Raichur district in the northern Indian state of Karnataka continues to face significant water management challenges that threaten agricultural productivity and farmer livelihoods. This situation analysis report examines the root causes and contextual factors driving these water management problems.

Rainfall patterns in Raichur have become increasingly erratic due to climate change, with the district experiencing erratic rainfall and frequent dry spells over the last decade. Groundwater resources are limited, with evidence of fluoride and salinity contamination in many areas. While irrigation projects like the Narayanpur Right Bank Canal and Tungabhadra Left Bank Canal provide surface water, distribution is highly inequitable – head-end farmers capture most of the water, while tail-end farmers receive very little.

The transition to water-intensive crops like paddy, supported by government incentives, has led to overexploitation of water resources and land degradation through waterlogging and soil salinisation. Inadequate drainage infrastructure and lack of mechanisms for equitable water sharing further compound these problems. Climate change will likely exacerbate rainfall variability and water scarcity in the coming years.

Broader socio-economic trends like fragmentation of landholdings, rising cultivation costs, stagnant wage growth, indebtedness and ecological trends like land degradation have rendered agriculture economically unviable for smallholder farmers. This is driving ‘distress migration’ and landlessness. Policy support through subsidies and cash transfers has been inadequate in addressing the root causes.

However, pathways are emerging to address these complex challenges in a holistic manner. The state government’s upcoming canal automation project presents an opportunity for transformative change by empowering farmer groups with controlled water distribution. By mapping stakeholders in the region, we found that there is potential for innovative partnerships between government agencies, civil society, researchers and communities to facilitate institutional mechanisms for equitable, sustainable water sharing.

Through collaborative knowledge co-production processes like journey mapping farmers’ experiences, rural livelihood aspirations studies, scenario modelling, community visioning workshops and stakeholder roundtables, key principles are emerging on designing localised water-sharing institutions and required policy reforms. With strategic investments to facilitate and innovate solutions that reduce technology costs, and spur reforms that promote participatory irrigation management, Raichur could pioneer an equitable, climate-resilient model for water stewardship in agriculture.

1. The Raichur T-Lab

Historically, developed economies have seen increased per capita incomes as labour shifted from agriculture to formal non-farm sectors, leading to economic formalisation. However, recent studies in India suggest that the abandonment of agriculture by farmers is driven by distress rather than formalisation (Basole and Basu, 2011a, 2011b; Basole, 2022). With over half of India's population relying on agriculture, mainly small and marginal landholdings, distress is evident in rising debt-to-asset ratios and millions transitioning to agricultural labour. This distress stems from agriculture becoming unprofitable, exacerbated by the Green Revolution and economic liberalisation. Policy shifts favouring privatisation and corporatisation, such as the recent farm ordinances, and challenges like groundwater depletion and land degradation compound this distress. Access to water, markets, cultivation costs, and labour determines agricultural practices, yet inequitable water distribution persists, especially affecting marginalised groups in areas like Raichur district.

Figure 1: Raichur district map

Located in northeastern Karnataka and bordering Andhra Pradesh and Telangana states, Raichur (Figure 1) is predominantly an agricultural district with a significant population of pastoralist and agro-pastoralist communities. It falls in the Northern Maidan region, between 15° 33'- 16° 34' North latitudes and 76° 14'- 77° 36' East longitudes. It lies between two major rivers, the Krishna and the Tungabhadra. The district is bounded by Yadgir district in the north, by the Mahbubnagar district of Telangana towards the east (CGWB, 2013).

As indicated by the human development report issued by the Government of Karnataka (2022), the district fares poorly on several socio-economic indicators and is listed as an 'aspirational district' by the Niti Aayog (a policy think tank of the Indian government). Of the two million people in the district, nearly 40% belong to Scheduled Caste-Scheduled Tribe social groups (Roy et al, 2015).

As per the 2011 census, nearly 80% of the population depended on firewood for cooking. Goat and sheep rearing have been identified as prioritised credit-lending activities by potential-linked credit plans developed by NABARD (National Bank for Agriculture and Rural Development). Raichur also fares poorly in terms of child mortality rates, maternal mortality rates, household access to cooking fuels, literacy rates, households with pucca houses (i.e. dwellings that are designed to be solid and permanent), and access to safe drinking water.

1.1 Water is a limited resource in Raichur

Around 70% of the population in Raichur depends on agriculture and allied activities for their livelihoods (District Census Handbook, 2011.) Raichur has a net sown area of 4,750 square km, out of which only 1,557.2 square km (around 33%) is irrigated. Figure 2 depicting land-use and land-cover map in Raichur district delineates agricultural lands with single cropping, double cropping and triple cropping depending upon the number of crop seasons in a year.

A higher cropping intensity (more than one season of agricultural crop) indicates availability of water either in the form of soil moisture or irrigation water from surface or groundwater. Around 72% of the total irrigated area is supplied by canals and 16% uses groundwater (Figure 3a).

Surprisingly, there is a reduction in the area irrigated by canals from 1962-67 (Figure 3b) – even though multiple irrigation projects were sanctioned during the 50-year period and the area irrigated by groundwater has increased considerably (Government of Karnataka 1970). The reduction in canal-irrigated area, even when the total area under irrigation has increased, indicates inefficiencies in surface irrigation systems including in terms of inequitable distribution of water.

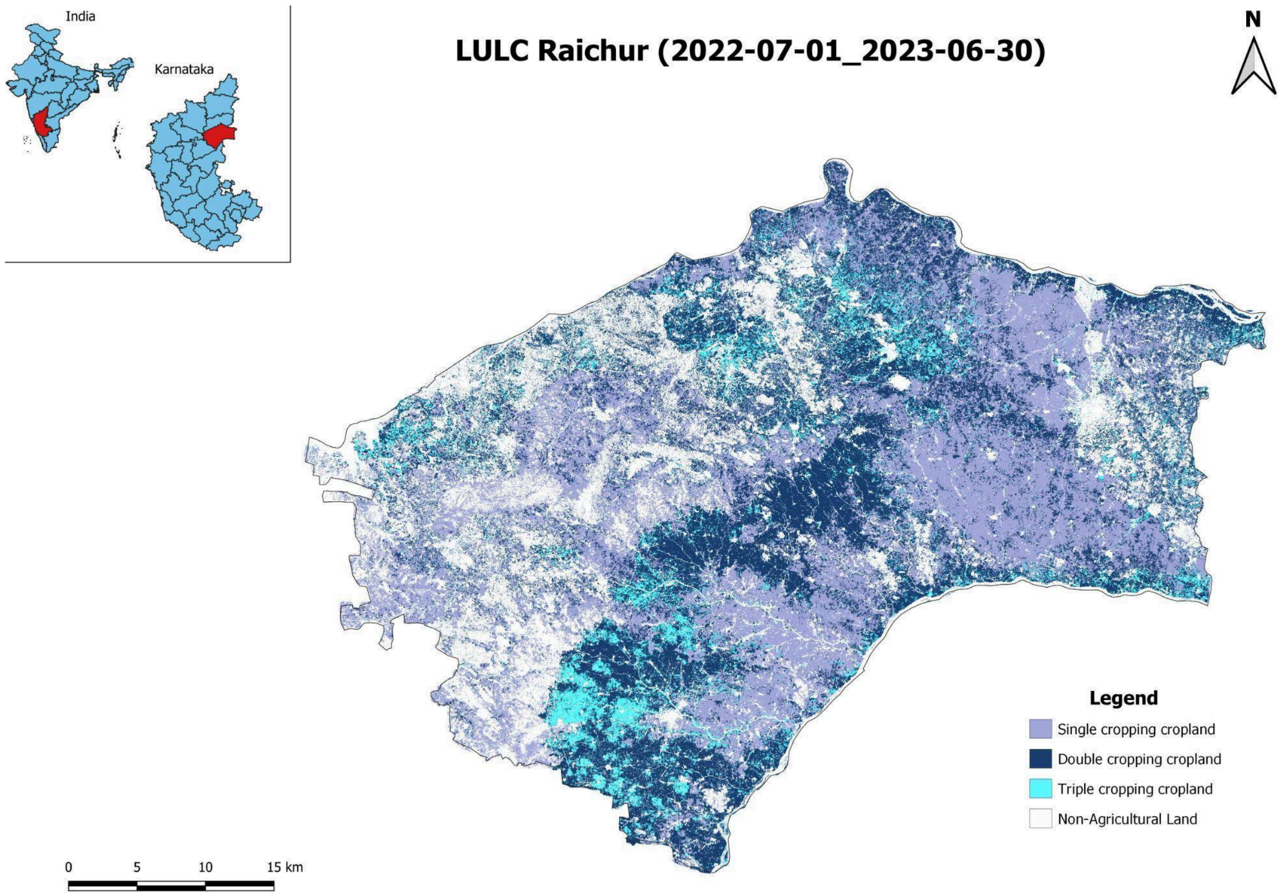
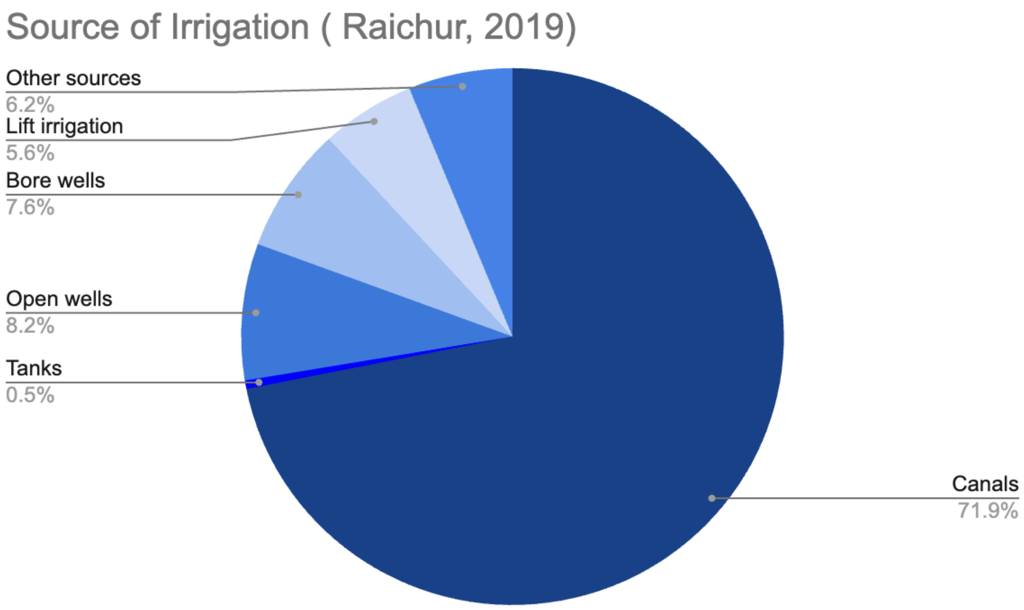


Figure 2: Land use land cover (LULC) maps developed by IIT and WELL Labs (2022-23)



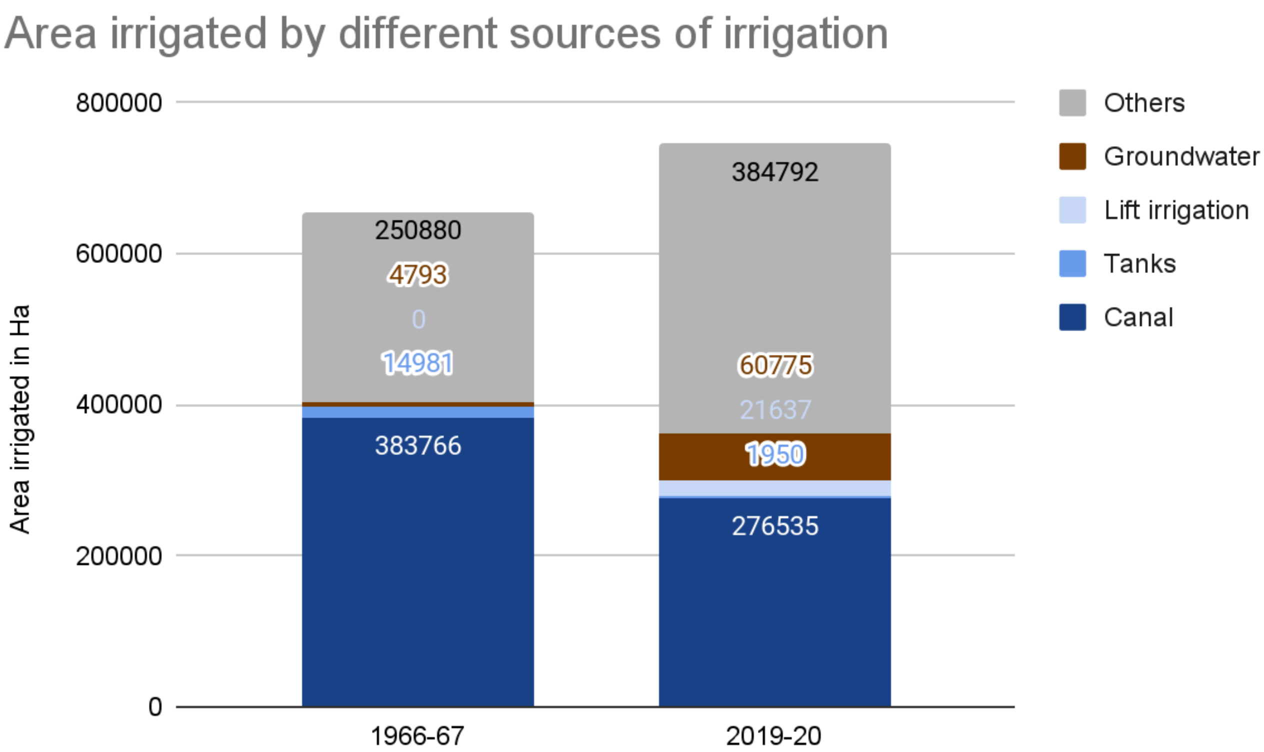
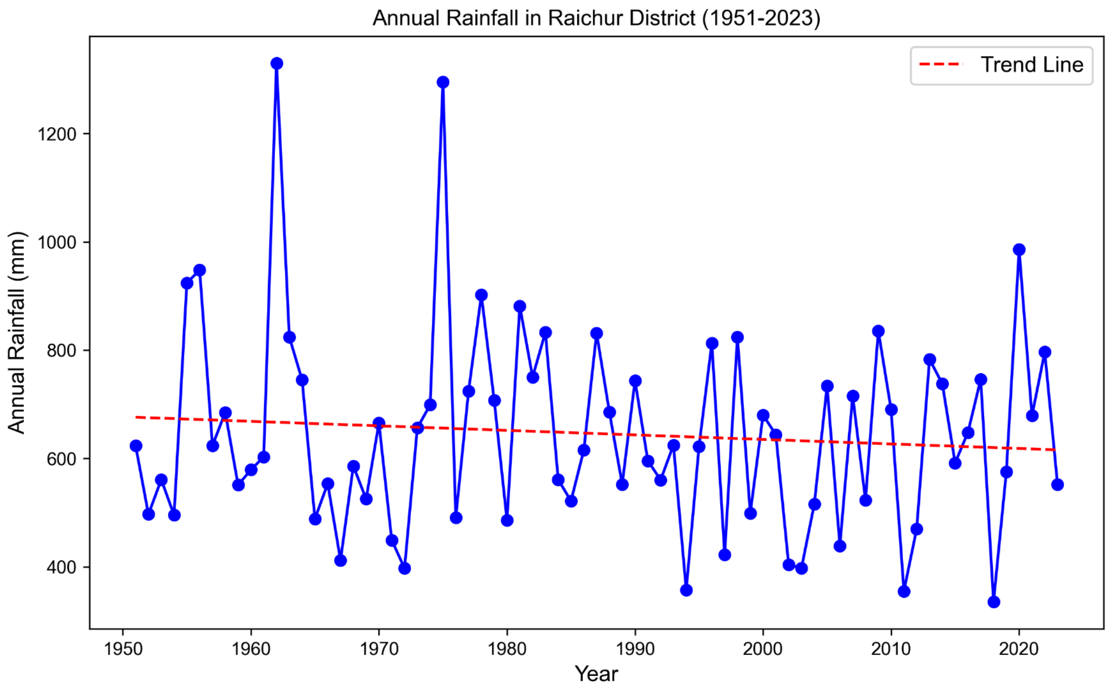


Figure 3a: Sources of irrigation in Raichur district (above) and Figure 3b: Shift in the extent of irrigated land based on source (below) (Department of Agriculture and Farmers' Welfare 1966-67 and 2019-20).

1.1.1. Rainfall

Since 2014, the district has experienced unpredictable and diminishing rainfall. In 2018, the Karnataka State Natural Disaster Monitoring Center (KSNDMC) officially declared Raichur to be in the grip of severe drought (Pal et al. 2022, 824). The district, therefore, falls within the 33% of the area in the country classified as chronically drought-prone.

Over the period from 1951 to 2023, Raichur experienced an average annual rainfall of 645 mm, with a discernible decreasing trend in annual precipitation. Erratic rainfall patterns with strong inter-annual variability (ranging from 335 to 1329 mm) characterise the precipitation in the region . To assess the projected impact of climate change on the region, downscaled debiased datasets covering the Indian subcontinent (Mishra et al., 2020) were utilised. The newly-developed climate predictions are driven by a bundle of land-use scenarios and emissions built on the Shared Socioeconomic Pathways (SSPs) scenarios, and new future social development pathways (O'Neill et al., 2016). The SSPs are based on five narratives describing alternative socio-economic developments, including sustainable development, regional rivalry, inequality, fossil-fueled development, and middle-of-the-road development (Riahi et al., 2017).



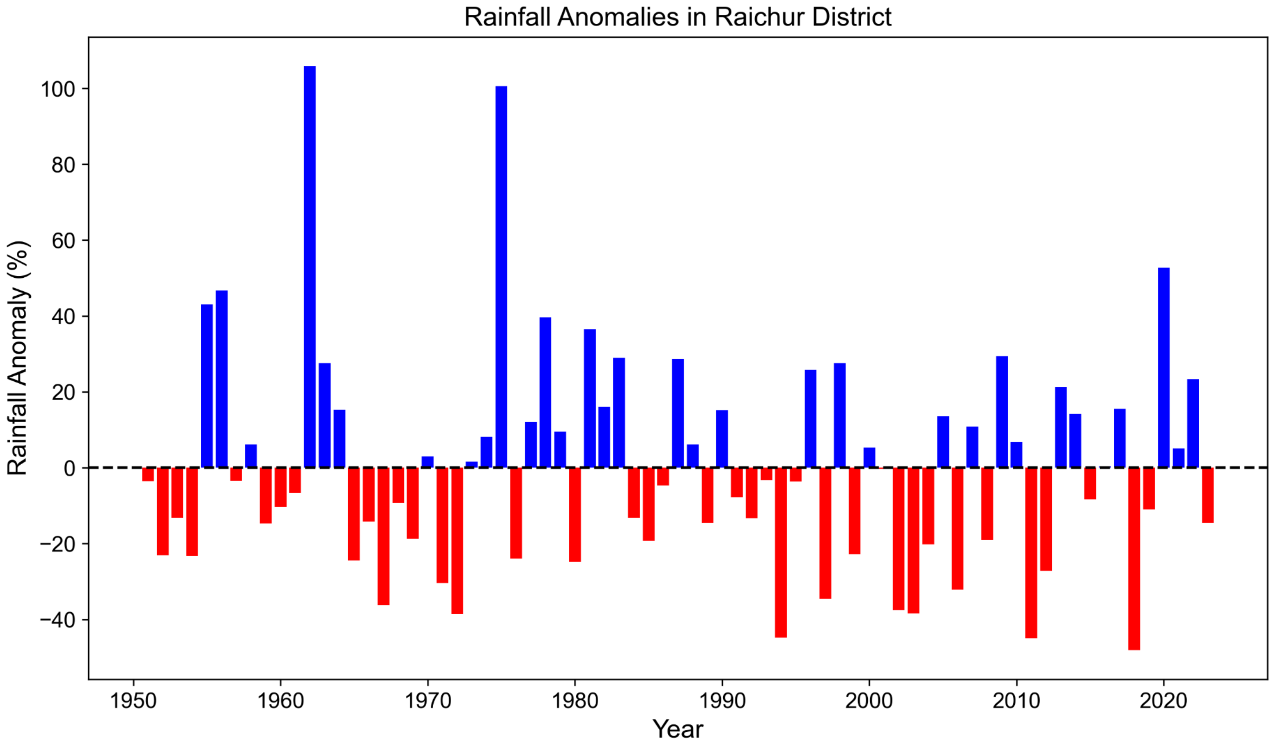


Figure 4: Annual Rainfall and anomalies in Raichur District (Data Source: IMD)

These datasets, representing four scenarios (SSP126, SSP245, SSP370, and SSP585) forced in the CMIP6 model, were used in the current study. **The projected precipitation trends exhibit pronounced inter-annual variation and the precipitation range varies according to these scenarios.** However, compared to the historical period, future projections show that there will be an overall increasing trend in precipitation. Furthermore, in all scenarios, it is projected that there will be a rise in extreme precipitation events over the region and frequency could be high during the middle of the century.

The temperature has also exhibited a rising trend over Raichur. The average maximum temperature rose by 0.68°C and the average minimum temperature rose by 1.0°C between 1951 and 2014 (IMD). In all projected climate scenarios, temperatures are expected to continue rising. It is anticipated that the minimum temperature will rise more than the maximum temperature.

This elevated temperature, coupled with increasingly frequent and intense rainfall events, are likely to adversely impact agricultural outputs and the regional economy.

1.1.2 Groundwater

The hydrogeological conditions in Raichur district are predominantly influenced by the presence of crystalline hard rocks such as granites, gneisses, and Dharwar schists. The parent rocks are often overalain by a layer of weathered rocks formed by the conversion of bedrock (saprock) to regolith (saprolite). There is a layer of stratified fractured rocks below the weathered rocks. This secondary porosity enhances permeability and water retention capabilities within these rocks. (CGWB, 2013.) With increasing depth the prevalence of fractures reduces in the bedrock. (Lachassagne, 2021).

Groundwater is primarily found under water table conditions within the weathered and fractured hard rock formations. Canal recharge due to the presence of two large canal systems leads to high levels of recharge and shallow groundwater levels. Deeper fractures may have water in semi-confined conditions.

Figure 5: Hydrogeology of Raichur (CGWB, 2013)

There are pockets of high salinity groundwater, especially in the southern parts of the district under the Tungabhadra Left Bank Canal. The reason for salinity is currently unclear and it may be exacerbated by high intensity surface water irrigation for over six decades. The prevalence of low conductivity black soils across the district hinders infiltration of diffuse recharge and the bad drainage conditions may be contributing to high salinity in certain areas.

The depth to the groundwater fluctuates between 0.4 metres below ground level (mbgl) to 8.3 mbgl during the pre-monsoon period and from 0.1 mbgl to 8.9 mbgl during the post-monsoon period. Over the decades, fluctuations between pre-monsoon and post-monsoon groundwater levels show both spikes and falls across various stations (Figure 6b).

Shallow aquifers, found primarily within weathered, semi-weathered, and partly fractured hard rocks up to approximately 30 mbgl, supply water mainly through dug wells, dug-cum-bore wells, and shallow bore wells. Medium to deep aquifers, located between depths of 30 to 100 mbgl, are tapped through bore wells and are crucial for drinking and irrigation purposes (CGWB, 2013).

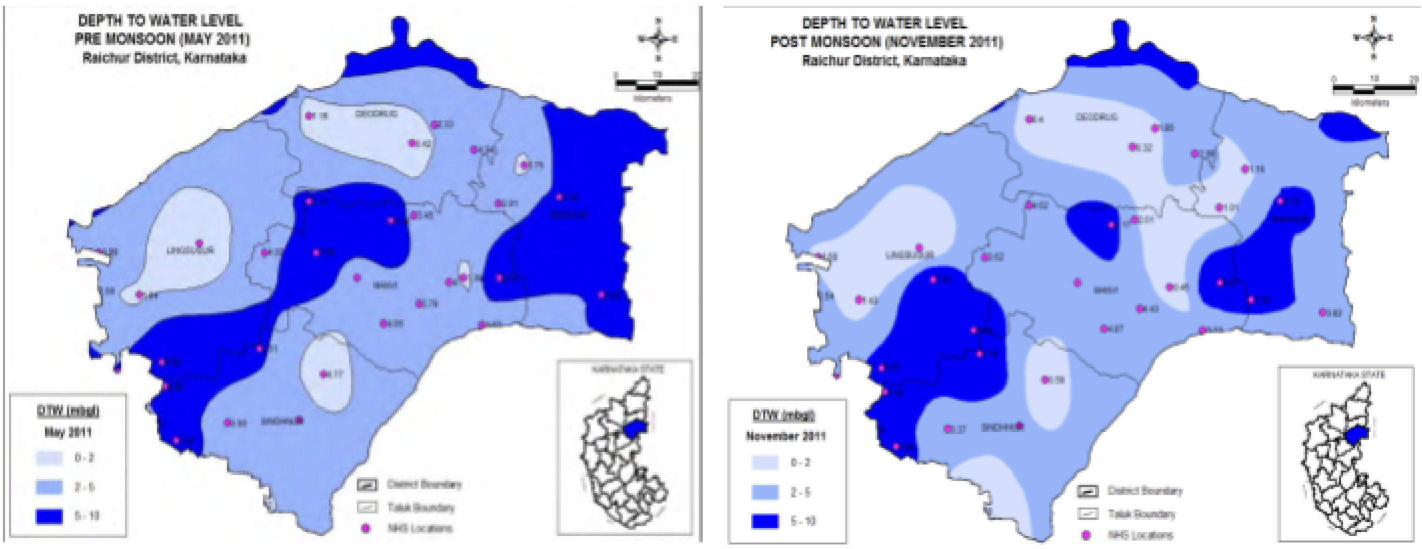
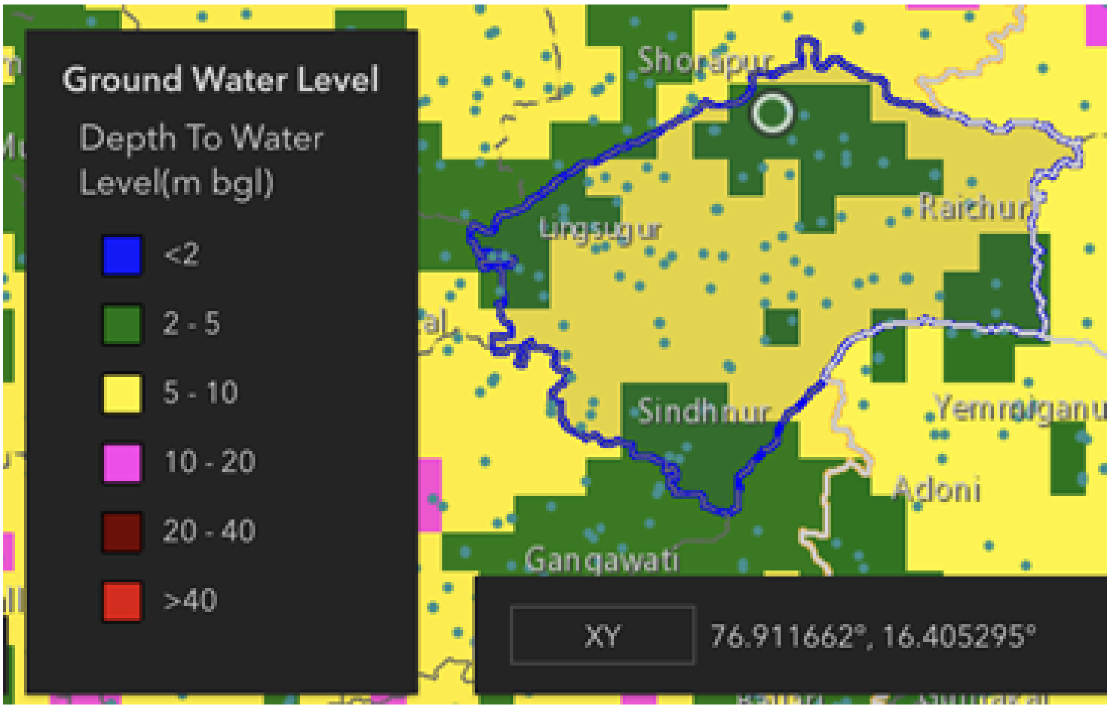


Figure 6: (a)Hydrogeology (above) and (b)Depth to groundwater (below) in Raichur District (CGWB, 2013)

As per the Raichur District brochure by the Central Ground Water Board (CGWB), groundwater quality assessments indicate that water in most parts of the district meets potable standards and is suitable for irrigation. However, fluoride contamination is prevalent in many areas, with concentrations exceeding permissible limits, leading to dental and skeletal health concerns.

Additionally, chemical analysis of groundwater samples reveals varying levels of electrical conductivity, chloride, and sodium absorption ratio (SAR), with instances of brackish and saline pockets particularly noted in specific boreholes. Some areas, notably Lingasugur, Raichur, and Sindhanur taluks, experience problems of salinity, rendering groundwater unsuitable for irrigation (CGWB, 2013).

Fluoride concentrations that range from 0.1 mg/l to 4.7 mg/l (maximum permissible concentration is 1.5 mg/l) limit groundwater use and only 5% of the total area is over-exploited (Department of Agriculture and Farmers' Welfare 2019).



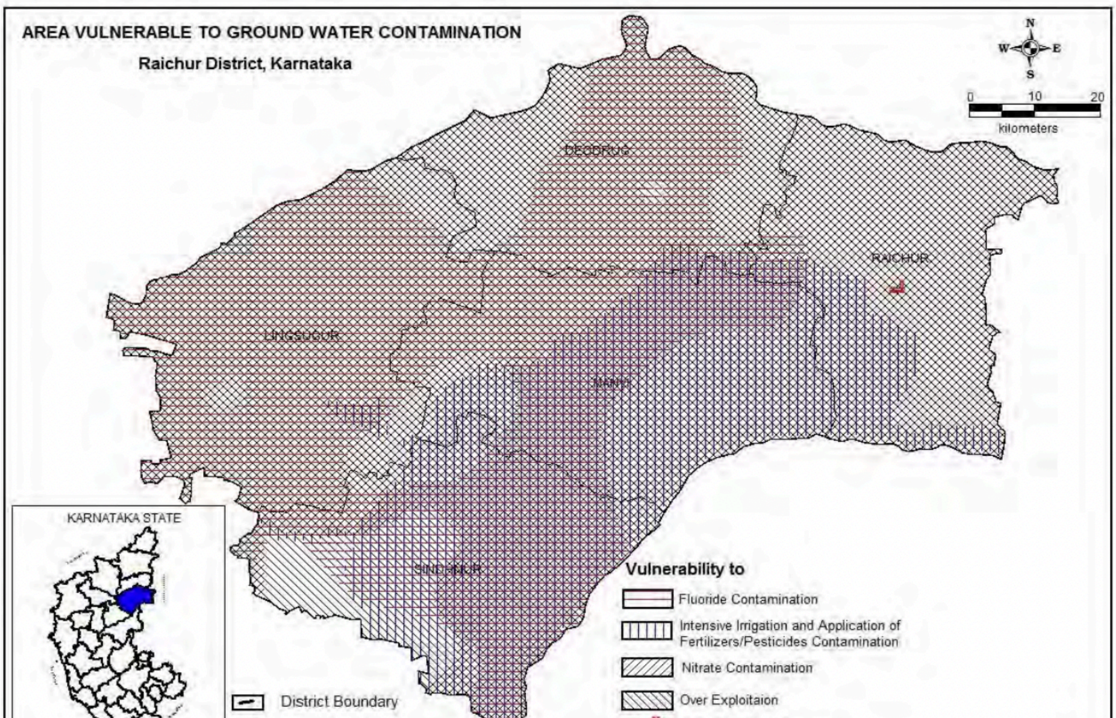


Figure 7: Latest information on depth to groundwater level (KWRIS) and areas vulnerable to groundwater contamination

1.1.3 Surface water

Raichur district is part of the larger Raichur Doab (land lying between two confluent rivers) between the Krishna river and its tributary, the Tungabhadra. The Krishna river, the third longest in India and fourth in terms of river basin area (Figure 8), passes through and provides irrigation to the Indian states of Maharashtra, Karnataka, Telangana and Andhra Pradesh. Around 43% of the river basin area (2,58,948 km^2) is part of Karnataka state and includes all of the Raichur district part of the basin (Ministry of Water Resources, 2014). Over the past few decades, aided by two irrigation projects – the Tungabhadra Left Bank Canal and Narayanapura Right Bank Canal – Raichur became known as the 'rice bowl' of Karnataka.

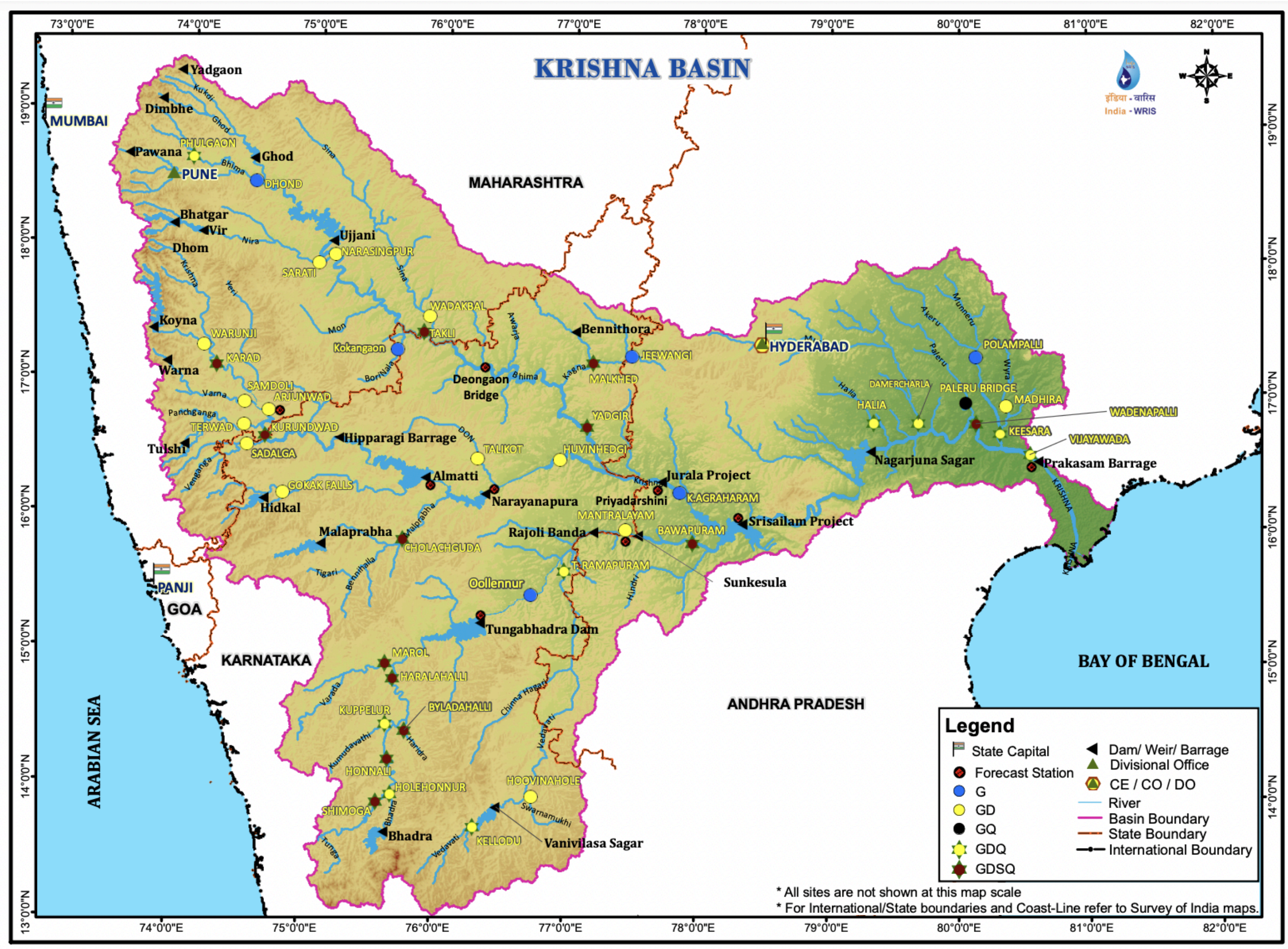


Figure 8a. [Krishna basin] (Ministry of water resources, 2014)

Apart from Narayanpur Right Bank Canal, part of Upper Krishna project, with potential irrigation area of 840 km^2 and Tungabhadra Left Bank Canal with irrigation potential of 2,500 km^2, there are medium-sized irrigation projects like Chitwadgi Medium Irrigation Project, Hirehalla Medium Irrigation Project, Kanakanala Medium Irrigation Project, Maskinala Medium Irrigation Project, and Rajolibanda Irrigation Project that serve Raichur district.

The canal network layers are merged with Raichur district elevation maps in Figure 8b; it is evident that elevated areas between NRBC and TLBC canals are not irrigated by these projects. Apart from that, due to higher elevation, canal infrastructure would not be able to serve certain areas even within the geographical limits of the command area as well.

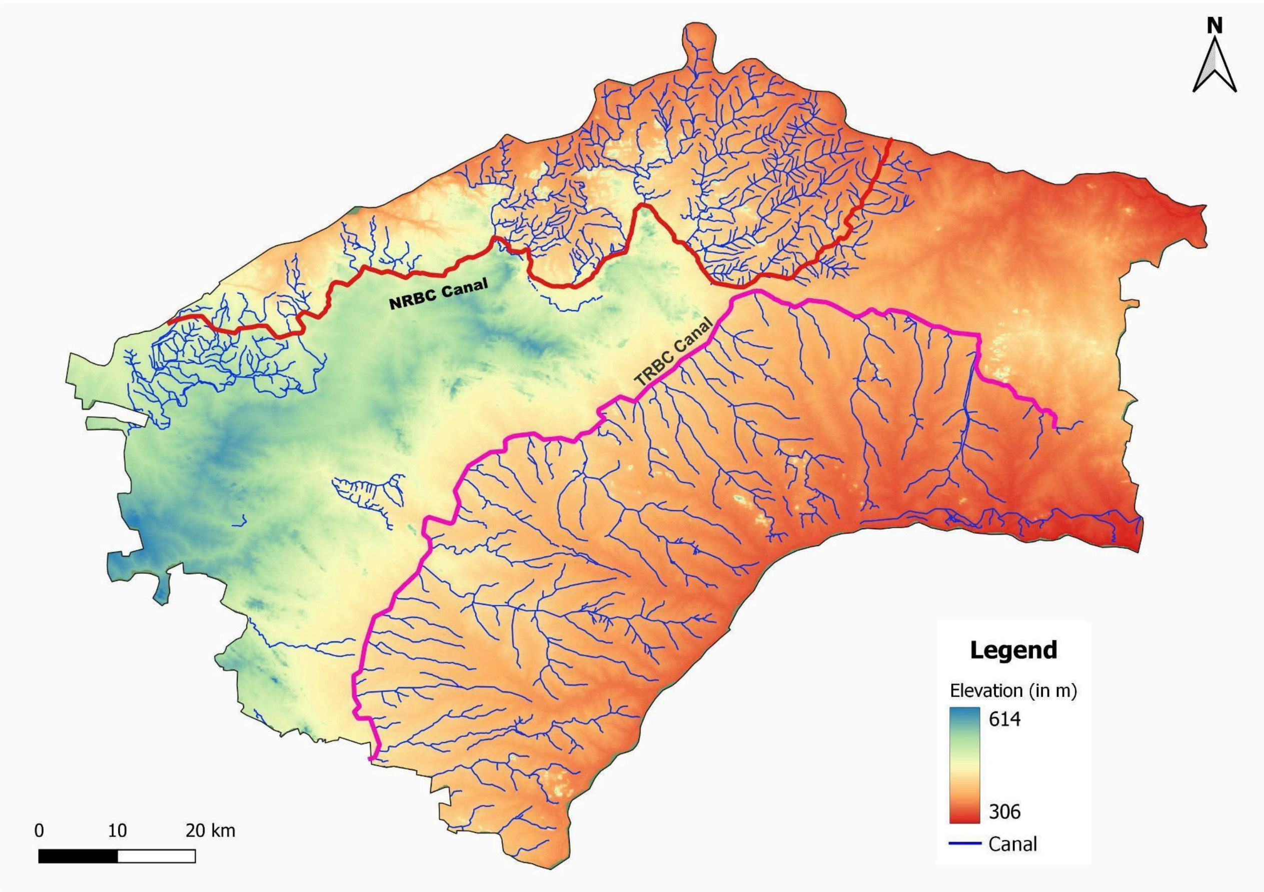


Figure 8b. Irrigation canal network in Raichur district elevation map (WELL Labs visualisation)

Box 1. Policy History

The evolution of irrigation projects has been incremental and spread over decades

The evolution of irrigation projects in Raichur district spans several decades, reflecting efforts to address the region's water challenges and enhance agricultural productivity.

Tungabhadra Project (1944):

The Tungabhadra Dam, initiated in 1944 by the erstwhile States of Madras and Hyderabad, was a pioneering effort to impound water in the reservoir for irrigation purposes. The dam, completed in 1958, facilitated the creation of canal systems, including the Left Bank Main Canal (LBMC) and the Right Bank High Level Canal (RBHLC), to provide water for agriculture. These canals played a crucial role in supplementing erratic rainfall and supporting kharif season crops (Karnataka Niravari Nigam Ltd, n.d.).

Lift Irrigation Schemes (1960s):

In the 1960s, the government of Karnataka undertook a program to establish lift irrigation schemes (LIS) in north Karnataka, including Raichur district. These schemes aimed to mitigate the effects of perpetual drought conditions by lifting water from available sources to irrigate agricultural lands. Despite their massive scale, many LIS faced operational challenges, resulting in sub-optimal functioning and underutilization of irrigation potential. (Kulkarni and Bokil, 2003)

Upper Krishna Project (1970s):

The Upper Krishna Project (UKP) emerged as a significant endeavour to harness water resources for irrigation in Raichur district. Originating from the River Krishna, the project aimed to utilise allocated water shares as per the Krishna Water Dispute Tribunal's (KWDT) adjudication. UKP's implementation involved the construction of storage reservoirs and canal networks to optimise water distribution for agricultural use.

Krishna BhagyaJala Nigam Ltd (1994):

To oversee the implementation of the UKP and other water projects in Karnataka, Krishna BhagyaJala Nigam Ltd (KBJNL) was established in 1994 as a government-owned entity. KBJNL played a pivotal role in coordinating various stages and phases of the UKP, ensuring the efficient utilisation of allocated water resources to meet agricultural demands in Raichur and surrounding areas.

Irrigation Acts and Policies:

The evolution of water policy in Raichur district has been shaped by legislative measures and policy frameworks aimed at regulating water resources and promoting sustainable irrigation practices. The Karnataka Irrigation Act of 1965, for example, provided a legal framework for the management and distribution of water for irrigation purposes, laying the foundation for subsequent initiatives.

Karnataka Irrigation Act of 1965:

The Karnataka Irrigation Act of 1965 marked a significant milestone in the regulation and management of water resources in the state, including Raichur district. This legislation provided a comprehensive legal framework for the development, distribution, and utilisation of water for irrigation purposes. It outlined provisions for the construction and maintenance of irrigation works, water licensing, and dispute resolution mechanisms, laying the groundwork for effective water governance in the region (Government of Karnataka, 1965).

Water Policy in Karnataka, 2022:

Karnataka's water policy framework has evolved over the years to address the challenges of water scarcity, agricultural development, and sustainability. The state government has formulated water policies that emphasise the efficient utilisation of water resources, promotion of water-saving technologies, and equitable distribution of water for various sectors, including agriculture, industry, and domestic use. These policies aim to balance competing water demands while ensuring the long-term sustainability of water supplies in Raichur district and across the state ("State Water Policy 2022", n.d.).

Overall, the evolution of irrigation acts and policies in Raichur district reflects the state government's commitment to effective water management, sustainable development, and equitable access to water resources for all stakeholders.

These initiatives represent the chronological evolution of irrigation projects and water policy in Raichur district, reflecting the region's ongoing efforts to address water scarcity, enhance irrigation infrastructure, and promote sustainable agricultural practices. Despite challenges and shortcomings, these initiatives mark significant milestones in the journey towards achieving water security and agricultural prosperity in Raichur and neighbouring regions.

Narayanpur Right Bank Canal with 18 distributaries is part of the Upper Krishna irrigation project.

2. Water management for agriculture

Despite its economic dynamism and government efforts, Karnataka state and its drought-prone districts like Raichur grapple with challenges in water resource management, particularly concerning competing demands and vulnerability to climate change (Asian Development Bank, n.d.)

Since the Green Revolution, the availability of surface water and groundwater for agriculture has led to a transition from diversified cropping systems to monocultures of water-intensive crops such as paddy, supported by institutional and market incentives. For example, a key driver of water-intensive agriculture has been the extension of credit for all forms of irrigation projects to state governments. This is because irrigation is recognised as a critical factor for improving cropping intensity and as a prerequisite for adopting high-yielding varieties of crops (Sidhu, 2002; Sarkar and Das, 2014).

In many parts of the country, as dam infrastructure becomes available, incentives are aligned for farmers to quickly switch to one or two paddy crops with heavy application of synthetic fertilisers and pesticides. Raichur is not different; with the advent of Tungabhadra left bank canal (TLBC) project and Narayanpur Right Bank Canal (NRBC), the same trend followed. Furthermore, because these projects were never intended for paddy but were designed for protective irrigation to support dryland crops and horticulture, there is simply not enough water for everyone to grow paddy.

The farmers near the dam, referred to as ‘head-end farmers’, capture most of the water, while farmers further downstream, known as "tail-end farmers," do not receive enough water. It is evident from Figure 9 that the head end of both NRBC and TLBC are categorised as double cropping or triple cropping in the Land Use Land Cover (LULC) map, whereas the tail end is mostly single cropping, especially in the case of longer distributaries. The point here is that tail-end farmers, usually belonging to more vulnerable, marginalised groups, cannot improve their incomes unless they gain access to water.

2.1 Inequitable distribution of canal-supplied water

Firstly, there is a ‘use it or lose it’ mindset. Farmers tend to overuse water even when they don’t necessarily need it because they cannot save it for later.

It's not that head-end farmers want to overuse water; the issue is that they lack incentives not to do so. The mechanisms and infrastructure for equitable sharing were never established. Water is made available through flooding of fields via feeder channels, and according to current regulations (Government of Karnataka, 1980), it cannot be stored locally for use in the dry season. Despite the potential for farmers to earn 2-5 times more money (net farmer income) with 30-50% less water (Chhatre et al., 2016), they remain locked in a low-level equilibrium of growing a single long paddy crop, due to the flooding irrigation regime, whereas they could cultivate two high-value horticulture crops if water was delivered in a more organised way.

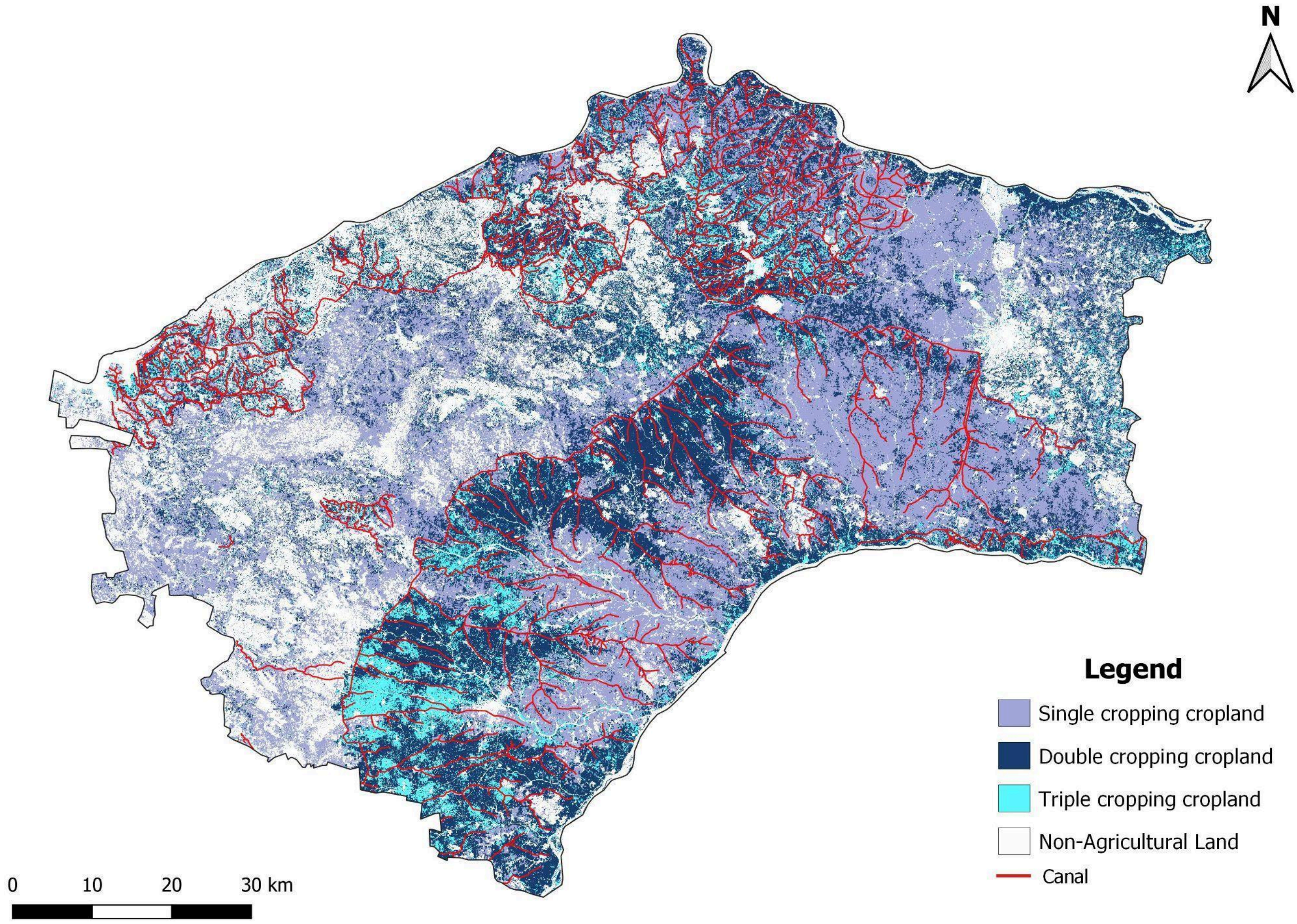


Figure 9: Canal networks in the land use land cover map

Second, public irrigation systems are designed independently of groundwater use. Groundwater is exploited primarily by private investments by farmers.

In areas both outside the canal command area and within the tail end of the canal system where water never reaches, groundwater is emerging as the primary source of irrigation. We found this to be the case in the village of Mandalgudda, a dryland village that falls in the tail end of NRBC canal networks (Figure 10). There are many tracts of agricultural land in tail-end villages that can be found to be categorised as double-cropped in LULCr maps (Figure 11); this can be mainly attributed to dependence on groundwater sources.

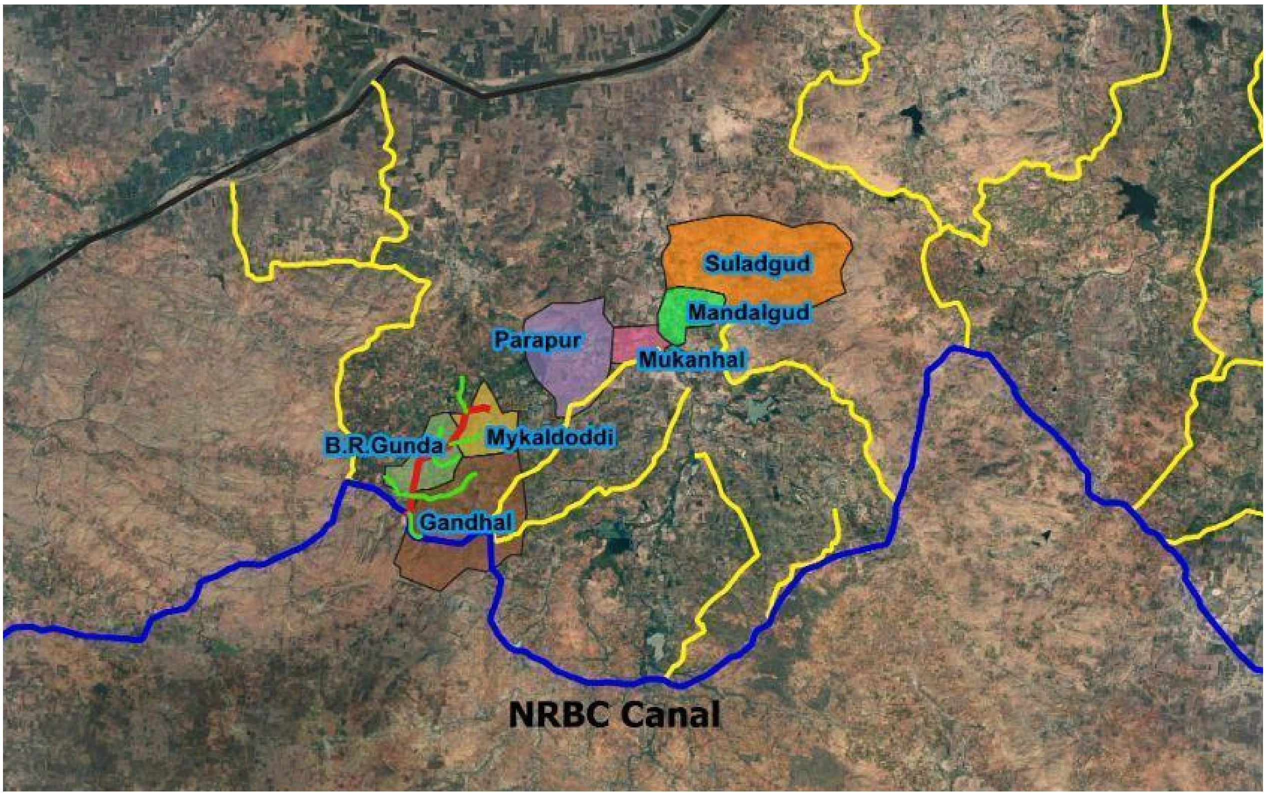


Figure 10. Pilot villages in NRBC command area and outside the command area

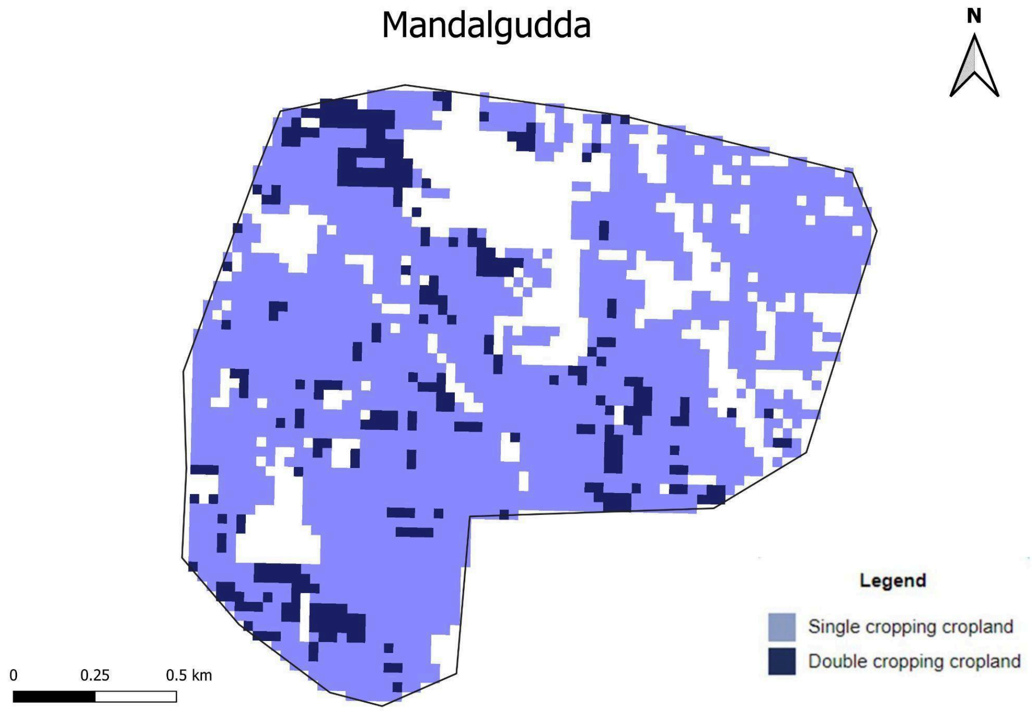


Figure 11. Mandalgudda village LULC map (IITD-LULC_2022-2023)

The shift towards private exploitation also has implications for equity in terms of resource distribution. Farmers no longer need to consider the common pool nature of groundwater and tend to make decisions purely based on profitability. Through participatory irrigation management strategies and institutionalising co-management, these issues can be addressed.

Thirdly, monoculture paddy systems degrade the land over time, but farmers often fail to perceive this degradation because it occurs gradually over decades.

In many areas where canals provide irrigation, improper water management has led to rising water tables and saline waterlogging, resulting in decreased crop productivity and soil fertility or the land even becoming barren. Approximately 8.40 million hectares of land in the country suffer from degradation due to waterlogging and soil salinity issues. Balakrishnan et al. (2008) estimated that Rs. 824 million would be needed for drainage and reclamation in the Upper Krishna Project area in Karnataka, with an expected annual net return of Rs. 326 million.

To ensure optimal use of irrigation water, current irrigation practices must be evaluated to ensure farmers receive dependable, timely, and adequate water supply. These issues are of serious concern in irrigation project areas, requiring priority attention to address land and water management to expand cropped areas vertically and enhance yields for profitable and sustainable irrigated agriculture (Balakrishnan, 2001). Synchronising cultivation and irrigation is only possible when water control, in terms of adequacy, timeliness, and uniformity, is practised within irrigation command areas (Skewes, 1998; Wang et al., 2004; Mujumdar et al., 2012). Balakrishnan et al. (2008) noted excess water flow in field irrigation channels and excessive irrigation at the field level, ranging from 27 to 211% and 11 to 26%, respectively, compared to requirements during various seasons. Conveyance and outlet losses ranged from 11 to 13% and 6 to 54%, respectively, while excess water applied to crops ranged from 11 to 29%.

Variations and unequal distribution of irrigation water continue to hinder productivity in many command areas, as Singandhupe and Sethi (2009) observed, excessive water at the head of channels and limited water at the tail end. Mishra et al. (2012) found insufficient water availability for paddy cultivation in the middle and tail reaches of the Eastern Yamuna Canal during the kharif season, prompting farmers to switch to sorghum. Conveyance efficiencies of 43-44% suggest potential for increasing water availability by addressing seepage and evaporation losses. A move away from conventional monoculture to low-input polyculture with better water economical crops like millets and sorghum ensures benefits for both the farmer and the ecosystem, both in the short term and long term.

Fourthly, the overuse of water in paddy cultivation leads to methane emissions, yet farmers lack incentives to adopt 'climate-smart' practices.

Apart from the very high water requirement of paddy compared to crops like pulses, legumes, oilseeds and cotton, rice cultivation globally contributes to anthropogenic warming as well due to methane (CH_4) emissions, mainly from flooding of rice fields. However, existing mitigation policies focus on reducing methane emissions by promoting intermittent flooding. Yet, scientific studies conducted on intermittently flooded rice farms in India by the Environmental Defense Fund (EDF) and its partners reveal that nitrous oxide (N_2O) emissions, a greenhouse gas that persists for a long time in the atmosphere, can be significantly higher compared to continuous flooding. Correlations suggest that intensified intermittent flooding may increase nitrous oxide emissions by 30-45 times (Nair et al., 2018; Kritee et al., 2018). Even though the flooding of paddy fields is a major contributor to the greenhouse gas emissions in agriculture, there are not enough incentives for farmers to change the cropping patterns, cultivation practices or irrigation methods.

2.2 Cross-sectoral demand for water

In Karnataka, water resources are strained due to escalating demands from urban and industrial sectors, exacerbated by the unequal spatial and temporal distribution of water resources and impacts of climate change. The state's water stress is evident in its limited water availability, with approximately 1,072 m^3 per person per year in eastward flowing rivers. Moreover, recurrent droughts, coupled with 70% of annual rainfall occurring from June to September, further strain water resources.

The agricultural sector, while critical for livelihoods, faces challenges such as low cropping intensities[1] of 110% to 125%, and irrigation efficiency (40%). Despite over 84% of state water resources being allocated for agriculture, the gross area irrigated falls short of its potential. Deficient infrastructure, management constraints, and inadequate promotion of water-saving crops and practices hinder irrigation efficiency.

Projections indicate a 40% increase in domestic water demand, particularly for industry and household use, from 37 km^3 in 2000 to 52 km^3 in 2025. This surge in demand is expected to reduce the proportion of water allocated to agriculture from 84% in 2000 to 73% by 2025, posing a challenge to sustainable economic growth.

Moreover, climate change projections for Karnataka anticipate increased temperatures, altered rainfall patterns, and heightened vulnerability to seasonal droughts, necessitating a comprehensive approach to water resource management. An integrated approach, guided by the state water policy, medium-term plan, and national water mission, aims to enhance water resource management through institutional strengthening, capacity building, and modernised infrastructure.

To address these challenges, Karnataka has proposed a substantial budget allocation of approximately $8.5 billion for water sector investments during the 2014-15 financial year to 2018-19, with a focus on achieving milestone performance targets. The state government seeks support from the Asian Development Bank (ADB) through a Multi-Tranche Financing Facility (MFF) to facilitate long-term lending, flexibility in project implementation, and institutional capacity building in Integrated Water Resources Management (IWRM).

[1] Cropping intensity is calculated as the ratio between net sown area and gross cropped area. The minimum cropping intensity for a plot of farmland is 100% and the maximum is 300%, which accounts for cultivation carried out over three seasons – *kharif, rabi and zaid.* A range of 110 to 125% implies a single season of cultivation, which fetches lower income than double or triple cropping.

In the context of the Raichur district, historical trends indicate an increasing demand for water resources driven by urbanisation, industrialisation, and agricultural activities. Presently, the district faces challenges in meeting water demands amidst competing uses and vulnerabilities to climate change. Projections suggest a continued rise in water demand, underscoring the urgency for sustainable water resource management strategies tailored to the district's unique needs and challenges.

2.3 Socio-economic and ecological drivers

In this section, we detail some of the ongoing trends or drivers of change in India's agrarian sector, in general, and particularly for resource-stressed regions like the Raichur T-Lab.

1) Fragmentation of agricultural landholdings makes agriculture economically unviable

The size of the landholdings has been consistently shrinking with every subsequent generation, predominantly due to inheritance laws. The small and marginal holdings taken together (0.00-2.00 ha) constituted 86% of the total land holdings in 2015-16. The all- India average size of holding is 1.08 ha. (Source: Agriculture Census, 2015-16). The small land sizes subsequently contribute to the trend of cultivators pushed towards informal wage labour. When compared to 2001, India recorded nearly 40 million more agricultural workers in 2011[2] and around 9 million fewer cultivators.[3]

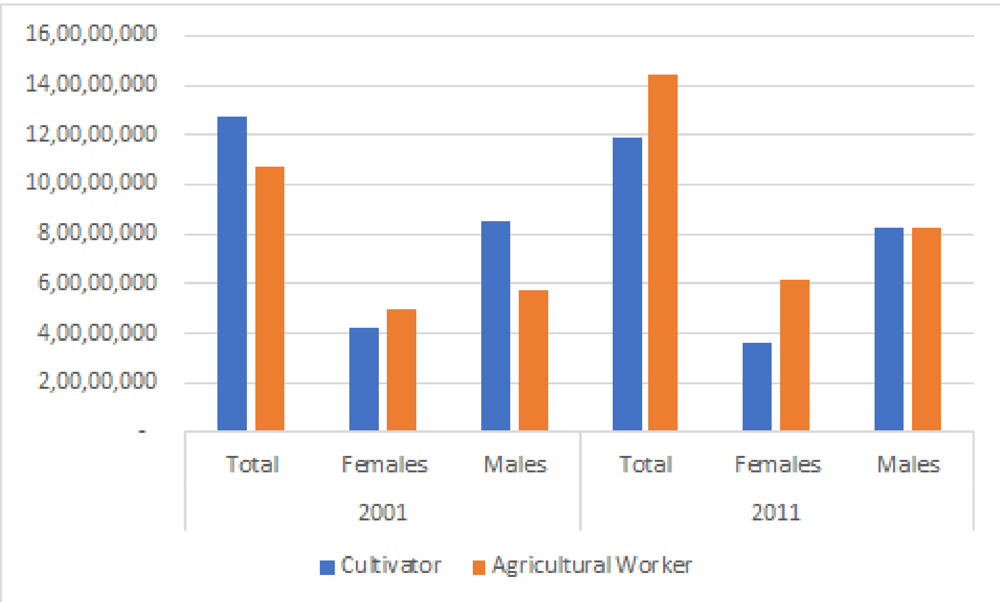


Figure 12. Gender disaggregated classification of male and female workers and cultivators in India (Census 2001[1] and Census 2011a[2])

[2] "A person who works on another person's land for wages in money or kind or share is regarded as an agricultural labourer. She or he has no risk in the cultivation, but merely works on another person's land for wages" (Census, 2011a).

[3] "A person is classified as cultivator if he or she is engaged in cultivation of land owned or held from Government or held from private persons or institutions for payment in money, kind or share" (Census, 2011a).

We assume this trend reflects the increasing unviability of agriculture for small and marginal households and representative of their need to adopt a pluri-livelihood strategy increasingly dependent on sources of income other than cultivation. To illustrate this squeeze, a member of an agricultural household earned around Rs 214 a month, according to the Government of India's Committee on Doubling of Farmers' Income, 2018. But his/her expenditure was about Rs 207 a month. In simple terms, a member had a disposal income of just Rs 7 a month. This has consequently resulted in the share of household income from farming decreasing from 3/4th of the total household income to 1/3rd of it from between 1970 and 2015. Even if the monthly income of agricultural HHs increased between 2012-13 and 2018-19, income from cultivation went down from 48% to 38%. Wage and income from livestock dominated the income shares.

2) The problem of extreme climate impacts land degradation and water stress.

Increasing climate variability and extreme weather events such as droughts and floods, result not only in direct crop losses, but also in false starts, which increase the cost of cultivation. Loss of seeds due to premature sowing is a common phenomenon which increases farmers' already high costs and makes them susceptible to debt cycles.

Caption: Algae spreads over a paddy field in Raichur as a result of overuse of chemical fertilisers. Credit: Manjunatha G.

Further, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services' (IPBES) report on land degradation recognises combating land degradation as a critical and urgent priority for human well-being. According to the report, restoration of degraded lands, "makes sound economic sense, resulting in, inter-alia, increased food and water security, increased employment, improved gender equality, and avoidance of conflict and migration" (IPBES and Willemen, 2019). For India, a recent assessment conducted by AREST (Alliance for Reversing Ecosystems Services Threats) estimates nearly ten million hectares of agricultural land with a dependent population of 90 million people in peninsular India are undergoing degrees of degradation. India also faces severe groundwater stress, which disproportionately impacts the vulnerable and marginalised communities, also inducing economic losses and distress migration.

3) Rising uncertainty in income earned from agriculture, stagnant wage incomes:

Furthermore, the income is not stable due to changes in monsoon patterns, increasing land degradation, and market price fluctuations. For instance, in the Mukkanal village of Raichur district, the yield per acre of pearl millet in degraded agricultural land is 5 quintals compared to 10 quintals in fertile lands elsewhere. To fight yield reduction, farmers use chemical inputs excessively, which increases the total cost of cultivation.

Welfare economist Jean Drèze recently analysed the growth in real wages for India. Between 2014 to 2021, for India's labourers, wages have increased by less than 1 percent across agriculture, construction and non-agricultural sectors. For these eight years, the average consumer price inflation stood at 6%. This means that the ability of the poor to be able to save and spend on improving their quality of life remains severely hampered (Dreze, 2023).

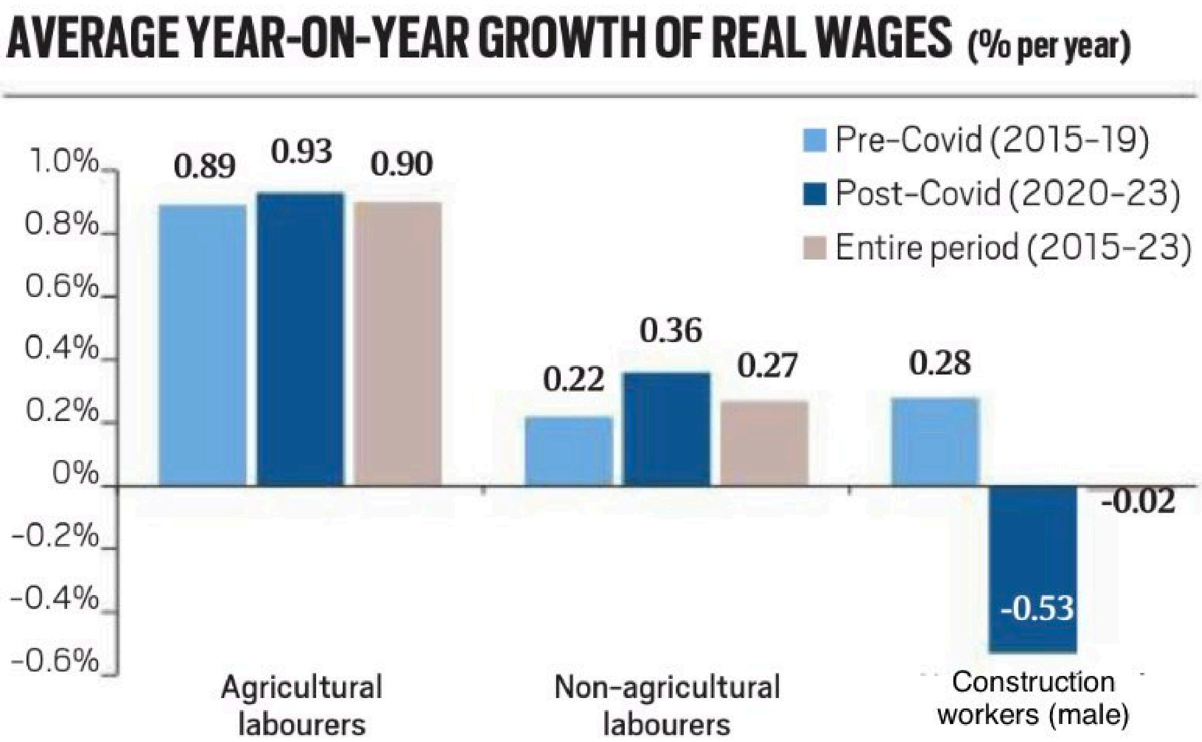


Figure 12. Average year-on-year growth of real wages (Source: Dreze, 2023)

4) Debt traps and rising input costs from ad hoc use of fertilisers and pesticides:

A journey mapping exercise (unpublished) conducted by researchers from WELL Labs in Raichur shows that for every Rs. 100 spent by the farmer on cultivation, approximately Rs. 66 is spent on chemical inputs. The excessive use of chemical fertilisers and pesticides also increases soil salinity and degradation, resulting in a vicious cycle, which further increases the risk involved in agriculture while also landing farmers in debt traps.

5) Landlessness, seasonal migration, distress migration, and feminisation of agriculture:

The phenomenon of smallholders migrating to nearby towns and cities to find jobs and better wages has become common in rural India. The aspirations study (Refer to Annexure A2) conducted in Mukkanal, Mundargi and Chadakalgudda villages in the Raichur district of Karnataka, shows that almost 70% of the households have a family member migrating for work either permanently or seasonally. Seasonal migration (more often than not, of men) has resulted in a feminisation of agriculture - a term to represent the situation of women taking much of the drudgery associated with the agriculture while the men continue to take care of the commercial aspects, compelling women to perform day to day agricultural labour with nearly 30% of total cultivators and 41% of agriculture labour being women. (GoI, 2018) Permanent migration, on the other hand, has led to lands being abandoned; and these lands would be taken up for long term lease or purchase by private companies for non-agricultural purposes including mega solar projects leading to increased landlessness. According to a 2008 paper, nearly 42% of rural households are landless (Kishore 2015).

6) Policy support and subsidy regime for the Sector:

Since the onset of the Green Revolution, and with the objective to make India food secure, a subsidy regime was introduced for incentivising agricultural production. Currently, budgetary support for the sector is prioritised in five ways (Chatterjee et al., 2022): (i) procurement and minimum price support in the form of an output subsidy; (ii) stock subsidy in the form of buffer stocks, and resulting interest charges; (iii) a fiscal subsidy to states by way of payment for the states' taxes and fees levied on agricultural output; (iv) fertiliser subsidy; and (v) direct income benefit or cash transfers to agricultural households under the PM-KISAN scheme started in 2019–20 (direct income benefit) and Pradhan Mantri Fasal BimaYojana (PMFBY) (Chatterjee et al., 2022; PIB, 2022). As per the authors' calculations, these benefits range on an average between Rs. 18,000 to Rs. 20,000 annually per agricultural household across the country. However, the efficacy of these schemes on actuals and accessibility will have to be validated.

3. Pathways towards better water management

An upcoming canal automation project funded by the World Bank ("Quotation Notification", n.d.) has the potential to transform canal-command areas in Raichur over the nest few years. The scheme aims to give farmers control over demand and timing of irrigation water. The scheme aims to give farmers control over timing the supply of water, opening up a huge opportunity to transform water use and prioritise equitable distribution.

3.1 Stakeholder mapping

We conducted a stakeholder mapping exercise in Devadurga *taluka* in Raichur to identify the community that the research addresses and key actors at the local and state levels.

Farmers and farmer collectives constitute the community in focus

For Raichur to transform, a diverse array of stakeholders must work towards a common understanding of the problems and how to address them. At the heart of it, is the farming communities of Raichur, who are directly involved in and affected by land and water policies.

According to National Commission of Farmers headed by one of India's most influential agricultural economist's, Dr M S Swaminathan, a farmer is defined as 'a person actively engaged in the economic and/or livelihood activity of growing crops and producing other primary agricultural commodities and includes all agricultural operational holders, cultivators, agricultural labourers, sharecroppers, tenants, poultry and livestock rearers, fishers, beekeepers, gardeners, pastoralists, non-corporate planters and planting labourers, as well as persons engaged in various farming-related occupations such as sericulture, vermiculture and agro-forestry. The term will also include tribal families/persons engaged in shifting cultivation and in the collection, use and sale of minor and non timber forest produce.'

According to this definition, around 54.6% of the Indian workforce is dependent on agriculture and allied activities (Economic Survey, 2020-21). Small and marginal farmers own 83% of the total landholdings and cultivate in 42% of the operated land. (Agriculture Census of India, 2015-16). In the Raichur T- Lab, this encompasses the following sub-groups:

Cultivators: Both full time and part time farmers who cultivate crops, utilising various land management practices and irrigation methods. Cultivators include small and marginal farmers (with operational land holding of less than 2 ha), women farmers (women members of farming families) and tenants or farmers cultivating in leased land.

Agriculture labourers: Predominantly composed of labourers relying on land and water in the form of agriculture labour. Their primary source of income is wage labour from agriculture and other land management activities including

Mahatma Gandhi National Rural Employment Guarantee Scheme. Apart from the landless, this group could also have an overlap with the above group, especially with small and marginal farmers whose dependance on wage labour is increasing. Share of agricultural labourers in the workforce dependent on agriculture increased from 40% in 1991 to 55% in 2011, which indicates we have more farm labourers than cultivators (Agriculture census of India, 2015-16).

Farmers being trained on composting systems suitable to their landscape for producing manure as a pre-sowing intervention for restoration of degraded lands. Credit: Manjunatha G.

Livestock owners: Individuals who own livestock and use the land for grazing or fodder. The Raichur region has a strong livestock rearing community who walks along the dryland region searching for grazing lands and water. They make a symbiotic relationship with land owners by penning or allowing grazing in harvested crop lands which improves the fertility of the soil with manure deposition. Apart from the livestock rearing community, above two sub groups - both landholders and agriculture labourers would also have livestock herds, especially small ruminants like goat or sheep in the region.

Farmer collectives (Water-User Associations, Labor Groups, Self-Help Groups, and Microenterprises): Farmers and agricultural labourers are formed into different collectives depending upon the purpose. Water user associations are supposed to be formed for every 500 Ha irrigated command area, which are largely non-existent. Local NGOs like Prarambha are trying to mobilise water user cooperative societies by federating farmer SHG groups around field irrigation channels.

Other actors and stakeholders need to be aligned for rural transformation

The stakeholders and key actors involved in the restoration efforts are pivotal for the success of the initiative. They include:

Civil Society Organisations: Engaged in natural resource management and rural development, involved in community mobilisation and intervention facilitation. NGOs will act as an extension of the community and will have a crucial role in mobilising communities, formation of water user groups and facilitating water sharing agreements.

Government Departments: State and local government functionaries especially part of various institutions under the Water Resource Department, Government of Karnataka. Various *Jal Nigams*, each for different irrigation projects, manage water distribution in the command area. The Command Area Development Authority (CADA) is responsible for mobilising the community, formation of the Water User Cooperative Society (WUCS) and establishing water sharing arrangements.

The Water and Land Management Institute (WALMI) is responsible for training farmers and water user association functionaries. ACIWRM (Advanced Centre for Integrated Water Resources Management) is a unique think tank within the Water Resource department of Karnataka Government enabling policy decisions towards increasing water productivity and equity with the help of data, research and technology. ACIWRM is also doing multiple research and implementation projects in Raichur to monitor water use efficiency and water productivity and conducts farmer water schools to ensure adoption of water efficient cultivation practices by farmers.

Apart from the above government departments, local self-government institutions like Gram Panchayath serve as important nodes for coordinating and implementing natural resource management activities..

Market Players: Market players are crucial stakeholders to ensure consistent market and fair prices for sustainable agriculture produce. Prarambha, the CSO partner in Raichur, has ongoing agreements with two market players promoting and distributing sustainable produce; 1) Safe Harvest, which procures staples and cereals cultivated by following Non-Pesticide Management (NPM) (without the use of synthetic pesticides) and 2) Kandu, promotes and procures an indigenous variety of cotton, brown in colour as an alternative to BT cotton from Janara Samuha Mutual Benefit Trust (JSMBT), a federated community organisation which acts as the intermediary between farmers and market players.

Research institutes and knowledge partners: Apart from WELL Labs - IFMR, which works with partner organisations for conducting research and innovative pilots, there are multiple other research-backed institutes who are directly working or working with the partners. University of Agriculture Sciences, Raichur is an important ICAR (Indian Council for Agriculture Research) backed research institution in the geography influencing farmer decisions on seed variants, soil improvement and nutrient advisories but with a limited reach.

The Indian Institute of Technology, Delhi, is collaborating with WELL Labs to generate land use land cover maps and other GIS based research outputs for the

T-Lab. WELL Labs also partnered with ATREE (Ashoka Trust for Research in Ecology and Environment) for coming up with a farm-scale trade off assessment tool as part of Sustainable and Healthy Food Systems (SHEFS) initiative. WELL Labs is also partnering with IHE Delft– World Water Institute situated in Delft, Netherlands, for leveraging remote sensing to achieve the goals of equitable distribution of irrigation water. And of course, the University College of London is a critical partner in establishing and nourishing the Raichur T-Lab as a model for the world in a holistic approach of research and rural transformation.

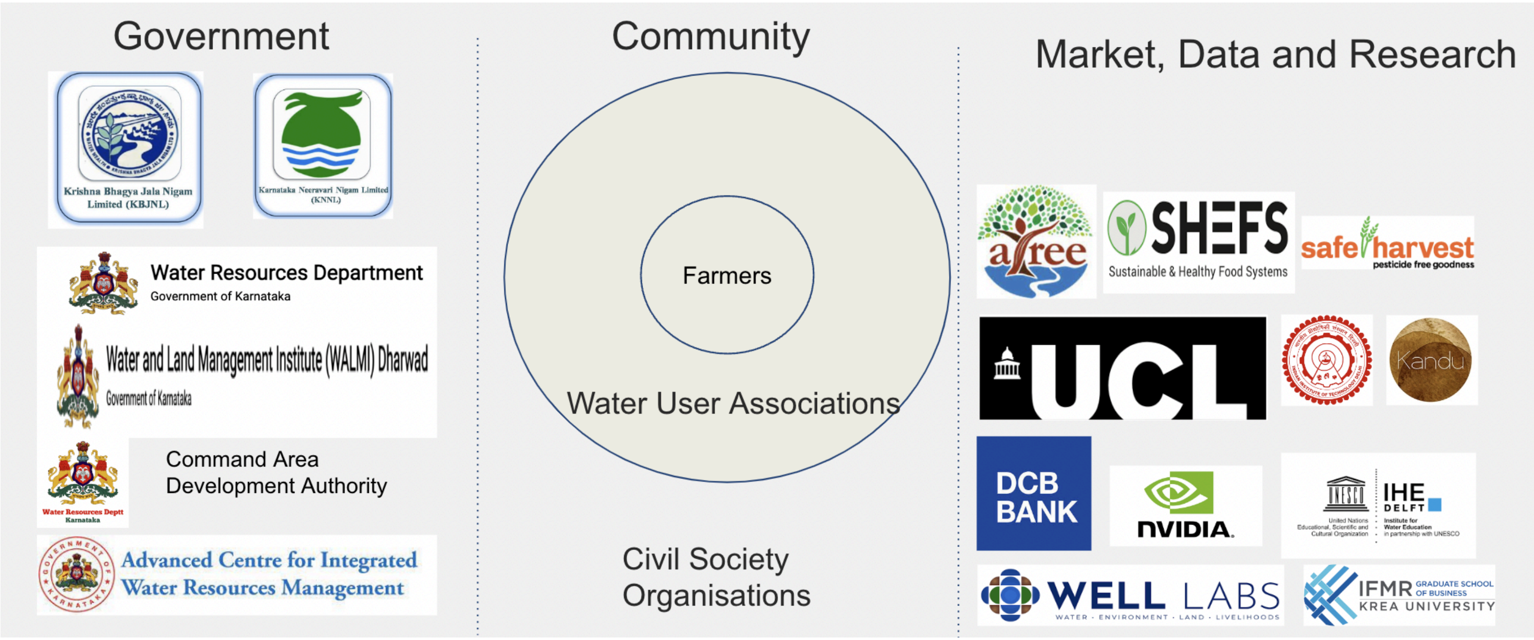


Figure 13: Community and actors

3.2 Knowledge is co-produced with the stakeholders

The mechanisms of knowledge co-production involved collaborative efforts among various stakeholders to generate actionable insights. The results from following exercises are incorporated in the above sections .

Journey mapping: Journey mapping exercise is carried out with identified farmers by understanding the material flow, finance flow and information flow during the course of crop season. A quantitative and qualitative analysis are done to understand the socioeconomic conditions and historical perspectives with special focus on cropping patterns.

Aspirations study: We conducted an aspirations study with around 200+ farmers in three villages to understand aspirations of the members of farmer households disaggregated based on gender and age.

Scenario modelling and tools: Multiple farm-scale scenarios are modelled to estimate net farmer income, water demand, fodder availability, fodder requirement, manure availability and carbon sequestration for different farm-choices. A tool was developed to aggregate farm choices in distributary scale in a LULC map based excel tool.

Community visioning workshops: Visioning workshops are conducted with farmers of 2 field irrigation channels part of lateral 1 A of distributary 10, NRBC project to understand the barriers for the farmers to adopt a diversified cropping system compared to monoculture paddy which is prevalent currently especially in the head end of the canal.

Stakeholder roundtables: A roundtable with important stakeholders working in the T-Lab is convened to understand the successful models for equitable water sharing, to identify bottlenecks for scaling up those models and make way for collaborations in the T-Lab for facilitating the protective irrigation through equitable distribution of available water. Stakeholders representing Government, Civil Society Organisations, Philanthropic and CSR organisations, market players and researchers participated in the roundtable.

3.3 Pathways are emerging from stakeholder interactions

Over the course of this research, we aim to work closely with the Advanced Centre for Integrated Water Resources Management (ACIWRM) and the Command Area Development Authority (CADA), two key government agencies, to mobilise the local community and create Water User Committees (WUCs). Traditionally, canal command areas have relied on open field channels where a lot of water tends to get wasted. If we are to have farmer groups control the water, we need innovative infrastructure and storage within canal command areas. This needs to be tested and piloted and, based on its success, serve as an example for the whole country.

To better understand existing gaps around water management in Raichur, we convened a roundtable involving sector experts and government officials. Here are a few key learnings:

1) Government needs civil society to create the spaces and facilitate WUCs

The NLBC project has 3,800 Water User Cooperative societies (WUCs). Many of these are only on paper and need facilitation to become more proactive. We know from past experiences that the civil society can play a critical role in supporting government institutions with social mobilisation and community engagement, especially when the state is constrained by the current constellation of players and their dynamics.

2) Water sharing institutions can only be developed by working at the speed of trust.

The hardest element in creating WUCs is that it is fundamentally difficult to get people to agree to water sharing – because there will be winners and losers. Multiple rounds of talks and negotiations need to take place to enable options such as participatory pooling and collectivising for shared borewells and ponds, that can help both ensure a more equitable distribution and avoid over-extraction. When successfully negotiated, there are cases where farmers have invested money to help create this shared resource.

3) There is a need to innovate and lower costs – current canal automation systems are too expensive.

There is huge scope to invest and research in bringing down the cost. At current costs, full-scale automation is too expensive; partial automation will also work. There is a business opportunity if the cost of this technology can be brought down, which would also make scaling possible and feasible.

4) There are nuances in WUCs in terms of design features.

Across the successful watersharing models, that we discussed as part of the Raichur Roundtable, a set of common design principles have already begun to emerge:

- ***Rotating leadership*** – giving equal weight to head, middle and tail-end farmers to formulate the rules.
- ***Inclusion of landless*** – ensuring that the share of water is not based only on land, but biomass needs of families, thus giving landless families a "stake in the resource".
- ***Matching the infrastructure to the institutions*** – ensuring that mechanisms for storage (ponds/ tanks) and pump energisation or piped distribution are included in the design to reduce losses and distribute water more evenly.
- ***Rules for wet and dry years*** – sharing arrangements often break down in drought years. These need to be negotiated and explicated.
- ***Order of priority (tail-end to head-end)*** – to ensure that tail reach farmers are not disadvantaged.
- ***Allocation based on land versus family members*** – The water allocation can be either based on land owned or the number of members in the household. The latter ensures equity by treating even the landless and livestock rearers fairly.
- ***Periodic updation of demand*** – recognising that demand is not static and evolves over time with changing land use, demographics and aspirations and therefore setting a period for revisiting the rules.

5) The water sharing institutions are constrained by current laws.

In all the shared cases, it was clear that compromises needed to be made to ensure compliance with current laws and regulations. While CSOs may lobby for long-term changes in policy, in the short-term, the only option is to adapt and work creatively within the constraints.

6) We need to invest in drainage to prevent water-logging.

In many canal command areas, drains that take excess water back to the stream are not constructed; this results in water-logging and eventually soil salinisation. The solution of installing drains is a well-established one but has been abandoned in recent projects.

7) Farmers are willing to pay borewell owners for water, if they receive water of reasonable quantity in a reliable and timely manner.

Across the case studies, it was clear that farmers are willing to pay land and borewell owners for irrigation if they know they can rely on it. The cost of using a diesel pump or worse, not having access to water, is very high. In fact, the single biggest return on investment is giving rainfed farmers access to a small quantum of water when they need it.

8) We need to collectively invest in donor education to fund facilitation

While funding is crucial, effective solutions require facilitation, which involves education, capacity building, and stakeholder engagement. The discussions at the Raichur Roundtable emphasised that simply throwing money at a problem won't solve it. Instead, there needs to be a focus on helping people understand and implement solutions. Government departments were able to argue for employing WUCS for maintenance works, citing the lack of manpower in their respective departments.

Annexure

A1. Hydrological and climatic monitoring/modelling data sets

The remote sensing based scenario modelling efforts seek to aid in improving the agricultural water productivity in the region. Efforts to improve agriculture water productivity of agriculture cannot be taken up in isolation. Farmers are the prime movers and the main metrics are increased income and reduced water demand.

With this in mind we sought to do an economic analysis to understand if there are pathways to sustainable agriculture with higher water productivity that simultaneously increase farmers income as well. We intended this to be the starting point for discussions with local farmers in irrigated command areas in Raichur district in the Krishna river basin.

Agricultural Land Use Land Cover maps have played a key role in this modelling and discussions with partners in the development of a vision and a roadmap for community action in the region.

Envisioning decision making with data and tools

The flow chart below illustrates the envisioned process flow for decision making based on data and modelling tools. Visioning workshops are conducted with communities to identify optimal transition pathways which ensure both income increase while improving the water productivity. A farm-scale trade off assessment tool (Figure A2) has been developed for this purpose as part of Sustainable and Healthy Food Systems (SHEFS) project and for assisted use of Civil Society Organisations. Crop planning exercise is the next step to gather individual farm choices and these are captured in an excel based aggregation tool (Figure A3) created with the help of remote sensing based LULC maps. Water demands are aggregated at field irrigation channel, lateral and distributary levels to estimate required monthly water releases and these demand based estimations can be integrated to water release decisions or gate automation systems, once implemented.

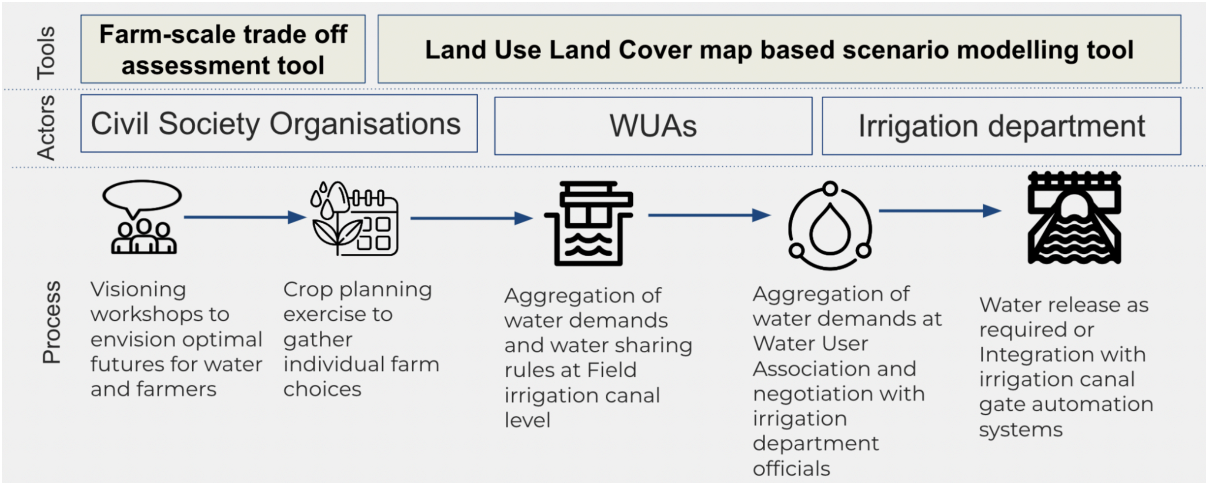


Figure A1: Envisioning decision making with the tools

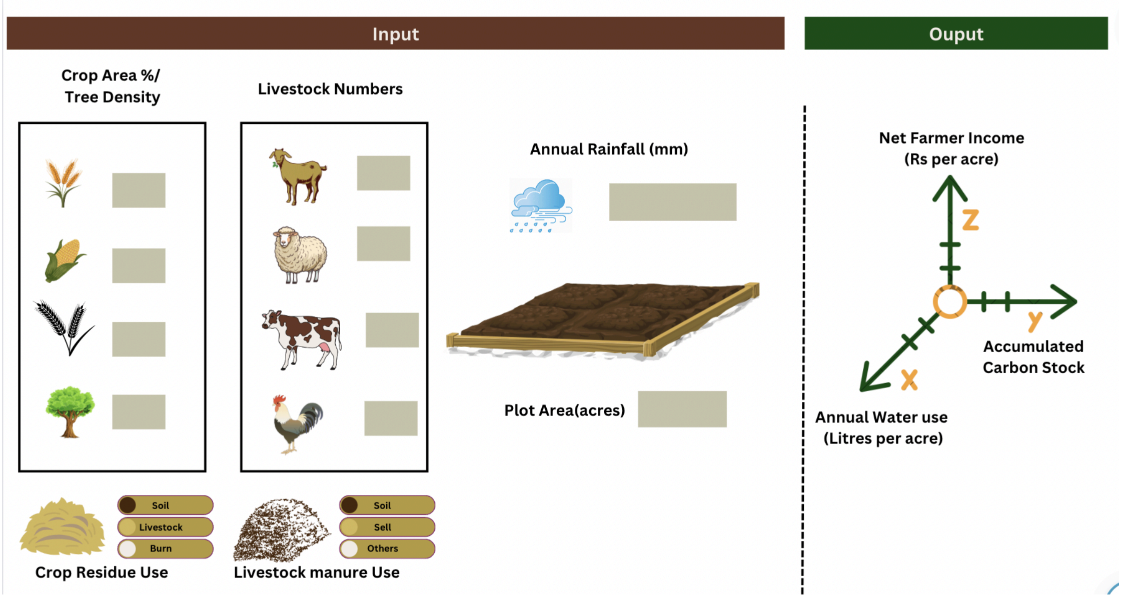


Figure A2: Farm-scale trade off assessment tool

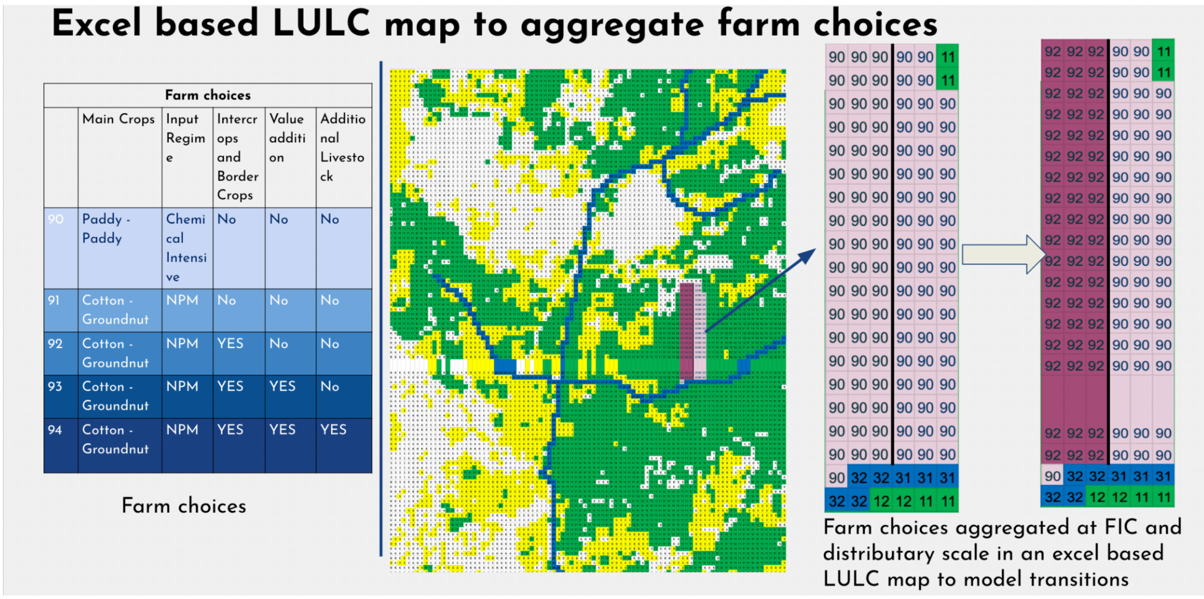


Figure A3: LULC based excel tool

The table below summarises the critical assumptions and references used for the scenario modelling:

Table A1: Assumptions and data sources for farm-scale modelling

Variables	Line Item	Data Asks	Calculation/ Assumption	Source
Income	Yield per acre	Harvested produce in Kg		https://www.indiabudget.gov.in/economicsurvey/doc/stat/tab117.pdf
	Net Farmer Income (Cost A2)	Revenue - cost per acre for each crop without considering family labor	Yield * price - Cost of cultivation (A2)	https://cacp.dacnet.nic.in/ViewQuestionare.aspx?Input=2&DocId=1&PageId=39&KeyId=818
	Net Farmer Income (Cost A2+FL)	Revenue - cost per acre for each crop considering family labor	Yield * price - Cost of cultivation (A2+FL)	https://cacp.dacnet.nic.in/ViewQuestionare.aspx?Input=2&DocId=1&PageId=39&KeyId=818
	Net Farmer Income (Primary)	Revenue - cost per acre for each crop without considering family labor		Prarambha
	% area for intercrops	Proportion of area covered by intercrops (in terms of number of lines/ saplings)	30% with 10% each for pulses, millets and oil seeds is assumed	Practitioner
	Border tree species	Fodder tree suitable to the region which can be planted in the border	*Alaintha Excelsa* is considered	Kavitha, A. et al. (2012) Common dryland trees of Karnataka: bilingual field guide. Bangalore: Ashoka Trust for Research in Ecology and the Environment.
	Density in number of trees per acre	No of trees per acre	Low -medium density (50 trees per acre) is assumed	https://ijpsr.com/bft-article/ailanthus-excelsa-roxb-maha-neem-an-holistic-insight-of-the-multipurpose-tree/
	Annual fodder yield	Annual fodder yield	*Aliantha Excelsa* leaves are rated as highly palatable and nutritious fodder for	https://www.researchgate.net/figure/A-Ailanthus-excelsa-tree-B-Leaves-C-Stem-bark_fig1

			sheep and goats and an average tree yields about 500-700 kg of green leaves twice a year.	_228375251
	Annual Firewood yield	Increase in Mechantable firewood volume	0.01 cubic meter per year as per lliterature	https://rfppl.co.in/subscription/upload_pdf/A%20Balasubramanian%203_9881.pdf
	Net farmer income from fodder	Price of firewood	Net Farmer income = Yield * Price - Cost (Cost is assumed as zero in later years)	https://www.semanticscholar.org/paper/Performance-of-agricultural-crops-under-Ailanthus-Ahlawat-Johar/a00b3e81b2ad75d79653d892823645d107d34448
	Net farmer income from firewood/ timber	Price of fodder	Net Farmer income = Yield * Price - Cost (Cost is assumed as zero in later years)	https://www.semanticscholar.org/paper/Performance-of-agricultural-crops-under-Ailanthus-Ahlawat-Johar/a00b3e81b2ad75d79653d892823645d107d34448
	Net farmer income from livestock	Net income from goat, sheep, Cow, Buffalo and Poultry	Revenue - maintenance cost (Net income from secondary data for multiple numbers of livestock is divided by the number of livestock to get income per unit)	1. https://www.manage.gov.in/stry&fcac/Project%20Report%20on%20Goat%20Farming.pdf 2. https://agritech.tnau.ac.in/banking/nabard_pdf/Animal%20husbandry/5.Sheep_Farming.pdf 3. https://www.dairyknowledge.in/dkp/content/10-crossbred-cow-farm 4.

				https://www.agrifarming.in/country-chicken-farming-project-report-cost-and-profit#google_vignette
	Value addition	Potential additional income from value addition	50 % share of net benefit from millet pre-processing unit apportioned for the per acre quantity	https://agriinfra.dac.gov.in/Documents/ModelDPR/cotton%20processing/FFF12AD3CFB1432AB2BD8A997CB05641.PDF
			50 % share of net benefit from cotton ginning unit apportioned for the per acre quantity	https://mpagro.org/ModalProjects/Malt%20Food%20Processing%20DPR%20by%20IIFPT.pdf
Water demand	Crop water requirement	Monthly crop water requirement		https://www.fao.org/3/X0490E/x0490e0b.htm
	Crop durations	Start date and end date of crops		Prarambha
	Canal line structure	Lined/Earthern		
	FIC structure	Lined/Earthern		
	Irrigation Mechanism	Flood/ Sprinkler/ Drip		

A2. Relevant academic and policy related literature/research –

- Research Brief 1 - unpublished
- Research Brief 2 - unpublished
- Research paper (SHEFS) - unpublished
- Policy Brief (SHEFS)- work in progress
- Aspirations study
- Journey mapping report
- Media articles
    - Diversifying Income Sources to Incentivise Smallholder Farmers
    - Envisioning an Equitable Transition to Regenerative Agriculture Using a 'Ladder' Approach
    - Restoring Landscapes and Improving Farmer Incomes, the People-Centric Way
    - Field Notes from Sittilingi Valley: How a Farmer Collective Addresses Both Healthcare & Agrarian Distress
    - A Package of Practices for Climate-Smart Agriculture

- The World Beneath Our Feet, Why Soil Biodiversity is Vital for Ecological Restoration
- [Commentary] Is agroecological farming a solution for rainfed degraded land?
- From Plural Livelihood to Schools: What people aspire for in Raichur
- Part 1: Mapping the Future of Mukkanal's Farmers
- Part 2: 5 Insights from Journey Mapping in Mukkannal
- Restoring Raichur's Degraded Land: How we studied the local context.
- Stakeholder Mapping: A Key Step for Restoration of Degraded Lands
- Soil Workshop in Raichur: Farmers Keen to Try New Methods to Rebuild Soils
- A Package of Practices for Climate-Smart Agriculture
- Explainer: How Green Manure Can Help Degraded Farmlands Sustain Themselves
- Pots Show the Way: A 2,000 year old irrigation system is being revived in north Karnataka
- Feeding humans has trapped the world in debt, degradation: FAO report
- Article on impact of NREGA TCBs on soil and moisture conservation

A3. Key contacts – local, regional/basin, national levels (potential sources of information; collaborators; 'change makers')

Name	Institutional Affiliation
Aaditeshwar S	Indian Institute of Technology Delhi
Amit K	Ernst & Young
Anuja Malhotra	ATREE
Arushi	Nudge Foundation
Bakka Reddy	WASSAN
Gaurav M	DCB Bank
Gayatri V	Labour Net
Gurudutt R	Arghyam
K J Joy	SOPPECOM
Manan B	ATREE
Neha B	SOPPECOM
Nikhil G	EDF
Omprakash P	Reliance Foundation

P S Rao	ACIWRM
P Suryakumar	-
Pooja P	IIT Delhi
Pragya M	IIT Delhi
Rangu Rao	Safe Harvest
Ravi	Udaanta/Kandu
Ravindra	WASSAN
S.S Ghanti	Prarambha
Saravanan S	Prarambha
Sashikumar N	ACIWRM
Shankar S	Prarambha
Siddharth B	ICC
Sonya F	Ashraya Trust
Sravya	Nudge Foundation
Sushma	Udaanta/Kandu
T N Reddy	ACIWRM
T Pradeep	Prarambha
Udaya BP	EDF (ex)
Vibha S	Villgro
Vikas H	Rainmatter Foundation

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